

# INDUCTION HEATING TECHNOLOGY

 **DKK Co., Ltd.**

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 **DKK Co., Ltd.**

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# Achieve Sustainable Heat Treatment with DKK

Heat treatment: to heat the metal up and cool it down. This is a processing technology to change the properties of metallic materials by heating up these materials and cooling them down immediately. In particular the hardening process, which increases the strength of metals, is an indispensable process for strengthening moving parts of vehicles and machines. Utilizing the high-frequency power current technology, DKK manufactures high-frequency induction heating equipment that performs various heat treatment processes such as hardening, tempering, annealing, and shrink-fitting. We support customers in achieving SDGs with our energy-saving and eco-friendly high-frequency heating technologies.



## Contributing to Social-Infrastructure Improvements

- Enhancing safety in the automotive industry
- Securing safety and quality

## Promoting Environmental Management

- Promoting carbon neutrality
- Efficiency in power consumption
- Expansion of environmental products

## Creation of New Business Opportunities

- New utilization of high-frequency technology

**DKK will work to actualize SDGs in 3 areas.**



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# Technology Utilization in Hi-Frequency Induction Heating Equipment

## High Frequency Generator

Achieves energy savings with high-efficiency transistor-type generator.

To perform high-frequency induction heating a high-frequency generator is required. This steadily supplies high-frequency power with specific frequency and output to the coil. We offer a wide range of generators from space-saving or eco-friendly models to models that support the highest levels of output power in the industry.

### Product Introduction by Model Type



#### ■ TRSC/CTG Series

High-response-speed model that simultaneously achieves both high output and digitalization even at high frequency bandwidth.

Supported Frequency Range: 30–450kHz  
Power Output: 5–300kW



#### ■ TRP/PTG Series

Capable of several thousand kW of power output, this is a marketable product with over 3,000 recorded units of sales in the world.

Supported Frequency Range: 0.3–50kHz  
Power Output: 10–3,000kW



#### ■ VFG Series

Through utilizing digital controls this product is compact. It has good power supply efficiency and suppresses cost.

Supported Frequency Range: 1–15kHz  
Power Output: 75–150kW

### Comparison with Evacuated Tubular Generator

Item	Generator Type		Advantages of Transistor Type
	Transistor Type	Vacuum Tube Type	
Total Efficiency	95%	60%	<b>Reduce Operation Cost</b>
Required Area	(width 3.8m) × (depth 0.8m) = <b>3.04m<sup>2</sup></b>	(width 6.6m) × (depth 1.5m) = <b>9.9m<sup>2</sup></b>	<b>Space Saving Reduce by 6.86m<sup>2</sup> Reduce by 69%</b>
Starting Performance	<b>Immediately</b>	Required Preheating Time	<b>Operation starts immediately after power is turned on.</b>

By committing to energy savings in the factory, a wide variety of subsidies and preferential tax systems become available.

### Actualized 2 Frequency Synthesis Hardening (Patent No. 4121719)

This is a technology to synthesize high and low frequencies applied in a single heating coil. For example, when a gear is inductively heated the tip of the gear thread is mainly heated by flowing the higher frequency, and the root of the gear thread is mainly heated by flowing the lower frequency. Therefore, synthesizing the two different frequencies enables uniform heating of both tip and the root of the gear thread.



## IoT Functions

### A New Ideal Way of Maintenance with Remote Controlling

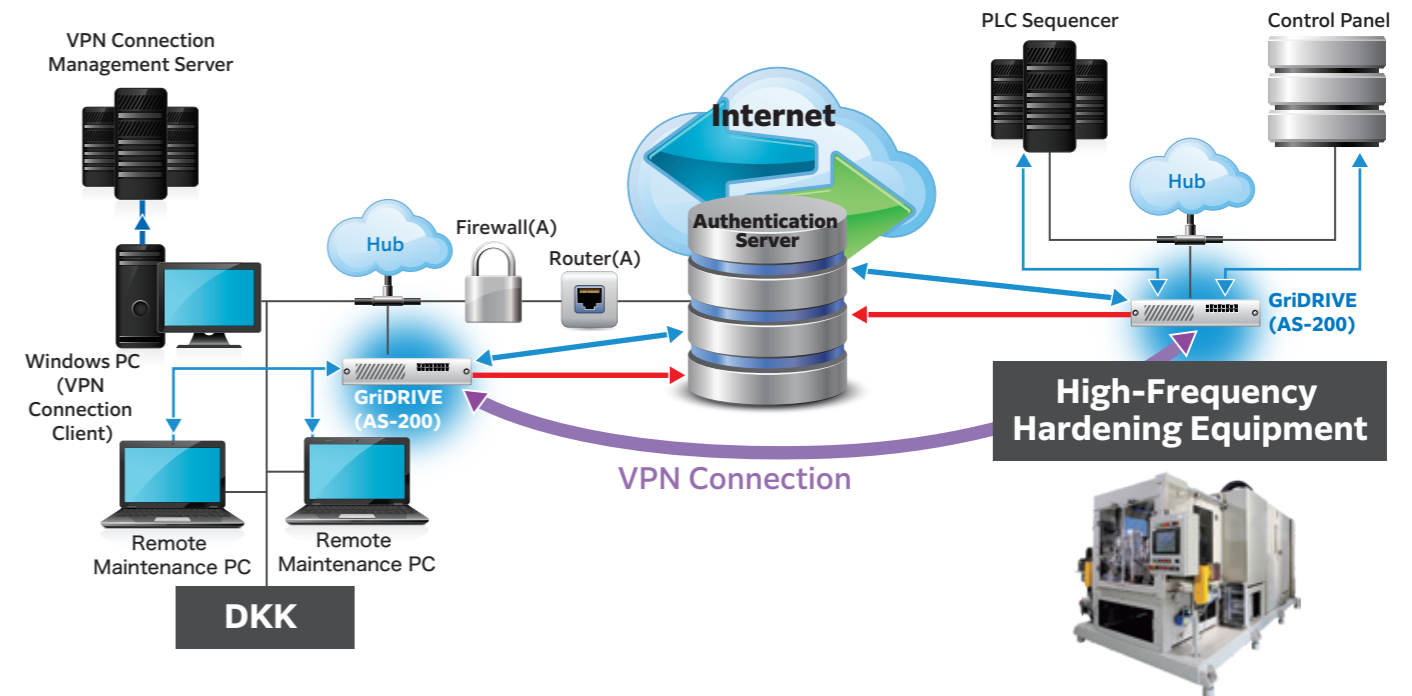
In the event of a problem at the customer's site, sending out engineers from our factory requires expenses and time. DKK leverages the IoT functions and offers a serviceable Remote Maintenance System, which fixes the problem while checking on the situation remotely from our factory. (May not be available depending on the situation.)

#### Remote Maintenance via VPN Line

Install a unit-type set box with VPN connection function in the control board. Accessible to the system remotely and safely from the outside through the existing network (Neither IP address modification nor static IP address are required). Equipment can be inspected and improved remotely.

#### Remote Maintenance with a Dedicated PC Kit

Connect a FA computer or a dedicated PC kit we provide. We will fully support and maintain customer's equipment with a remote connection by connecting to the network in a specified procedure.



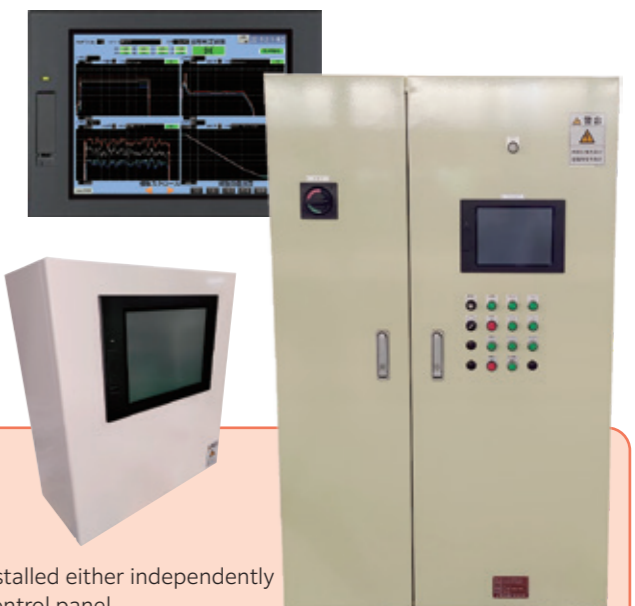
## DWM (DKK Waveform Monitor)

Workpiece quality can be visually monitored during machining by Waveform.

**Heat Monitoring** ● It monitors the workpiece quality by comparing the waveform pattern from a non-defective product to check whether the induction heating is performed reliably.

**Flow Volume Monitoring** ● It monitors the most important cooling process factor in hardening by comparing the waveform pattern from the non-defective product by capturing the flow meter value.

**Positioning Monitoring** ● It monitors whether the positional relationship between the coil and the workpiece is properly set by comparing the waveform pattern in reference to the servo and the displacement sensor value.



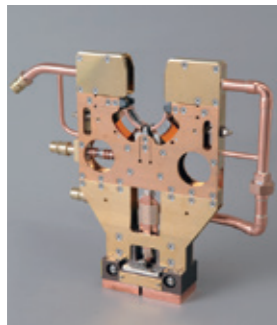
It can be installed either independently or on the control panel.

# Heating Coil Technology

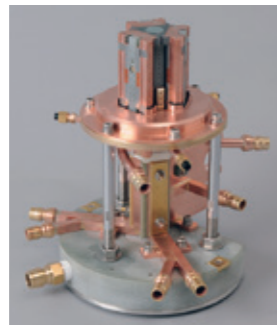
## Excellent Coil Design and Fabrication Technologies Based on Our Experience and Past Achievements

### Optimum Design and Manufacturing to Meet the Required Heat Treatment Specifications

Since the quality of high-frequency induction heating varies greatly depending on the shape of the coil and the positional relationship between the coil and the workpiece, the optimum coil design takes into consideration the shape and size of the workpiece. DKK provides one-of-a-kind custom designs and uses coils produced by skilled craftworkers to achieve heat treatment quality that meets the customer's requirements.



Crankshaft Hardening Coil



Inboard Groove One-Shot Induction Hardening Coil



CVJ Shaft Hardening Coil

## K-kahen (Diameter Variable) Heating Coil

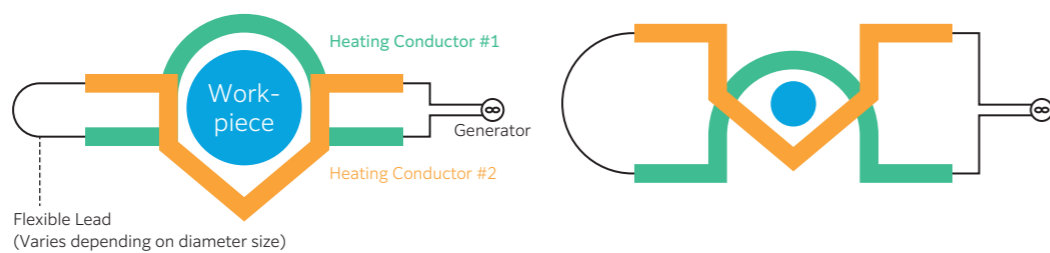
### New Mechanistic Heating Coil that Changes its Machining Diameter during Hardening

DKK has developed a new heating coil for movable hardening which can change its machining diameter to fit on the workpiece shape to have better working efficiency. This has made it possible to reduce the required number of coils and the replacement frequency. (Patent No. 4658027)

### Transformation Mechanism

● If the workpiece diameter is large

● If the workpiece diameter is small



### Appearance of Hardening Operation



## Heating Coil Fabrication using New 3D Printer Technology

### Coils to be Produced with 3D Forming Technology using Metallic Powder

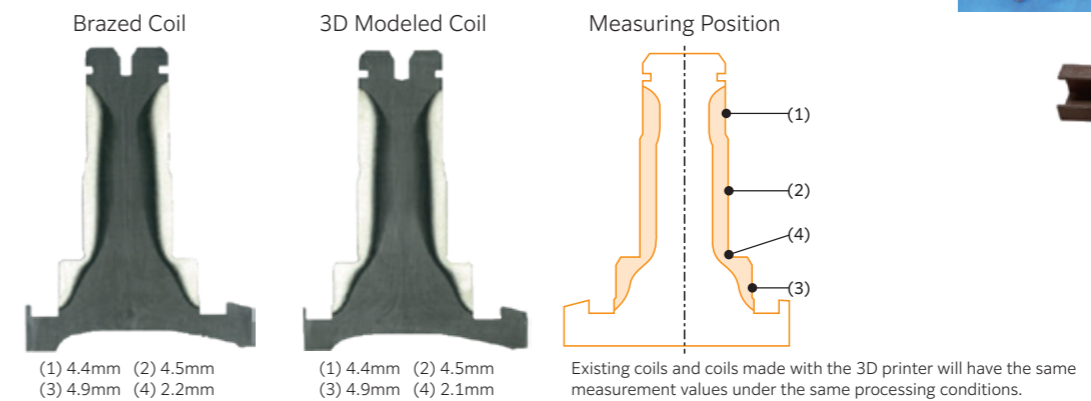
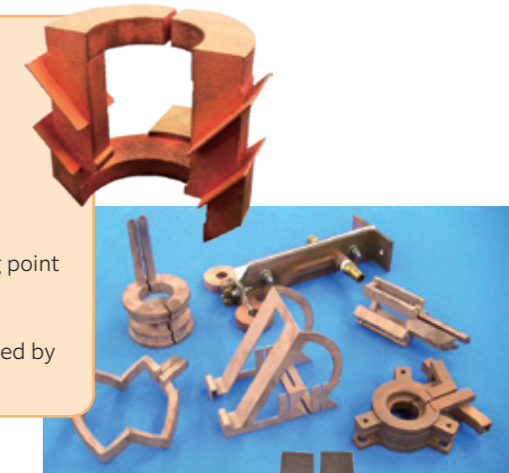
In recent years, the requirement for heat treatment quality has been becoming stricter as the product shape becomes more complicated and the cycle time is shortened. We highly recommend our 3D printer to produce your heating coils. Producing the heating coils with a 3D printer has a lot of merit as below.

**The Most Optimal Coil Design Method** ● In accordance with the condition of each target workpiece, a 3D printer enables production of complex shaped coils which are difficult to produce with general equipment.

**High Reproducibility in Coil Production** ● Even if the coil shape is complex, we can produce coils with high reproducibility without being affected by individual differences.

**Improvement of Durability** ● The coils produced with a 3D printer do not have a brazing point and have a small risk of water leakage.

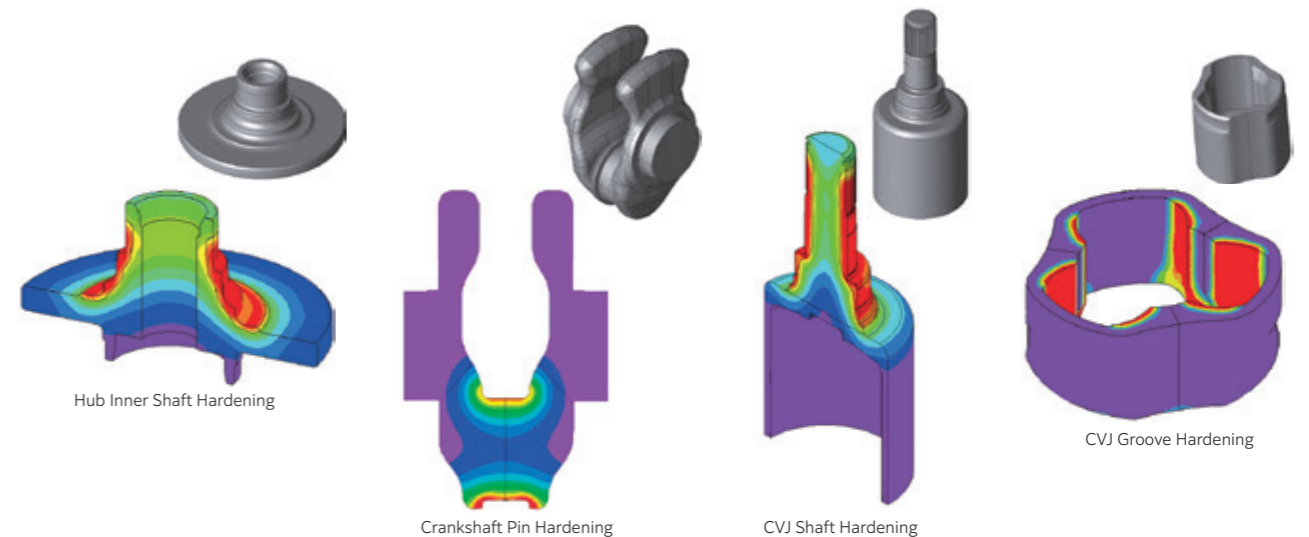
**Shortening the Production Lead Time** ● Production lead time can be drastically shortened by using a 3D printer for most of the working process.



## Heating Simulation Technology

### DKK suggests the most appropriate induction heating system to suit your needs with our extensive simulation method.

DKK utilizes our unique heating simulation to improve the heating quality and technology. DKK constantly strives to improve our analysis technology with feed-back from our extensive storage of simulation data. Furthermore, the original coil shape produced for analysis can be manufactured on the 3D printer and completely handled digitally from designing to quality-conditioning.



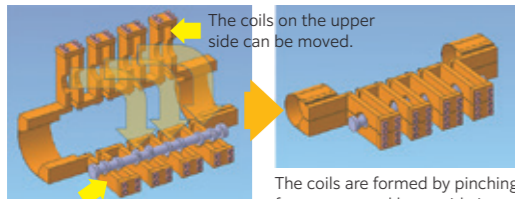
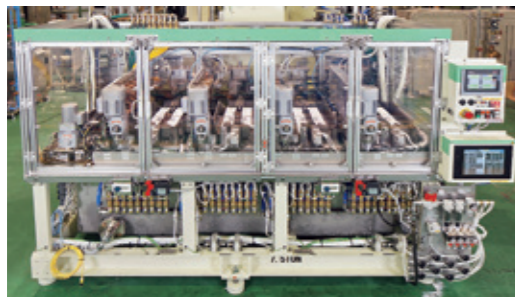
# Automobile (Gasoline Engines & Motors) & DKK

## Camshaft Hardening & Tempering Equipment

The specially shaped coils enable uniform hardening of cast materials without unwanted cracking.

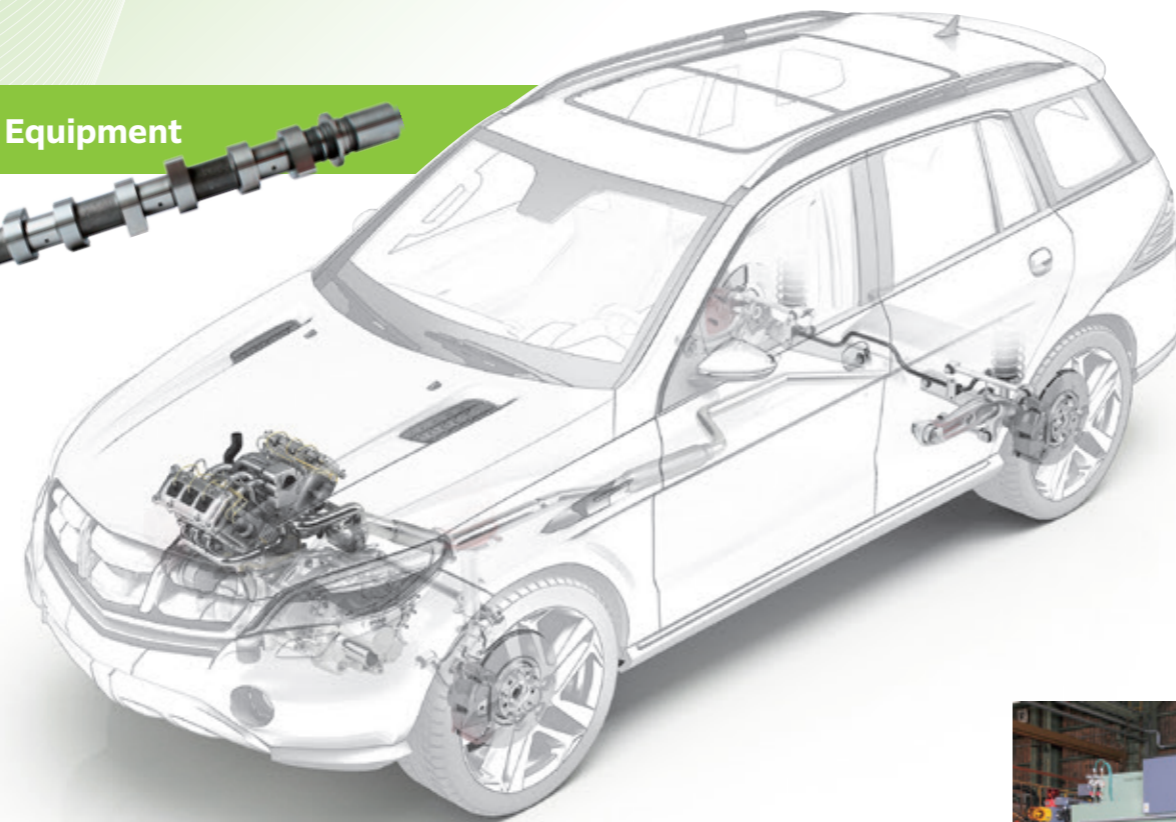
### ● Clamshell Method

The heating coil clamps down on the workpiece from above and below like a clamshell closes. This improves heating and cooling efficiency and ensures satisfactory product quality without any hardening crack initiation. Furthermore, we achieved a space savings of approximately 50% by downsizing the facility.



The coils on the lower side are fixed.

The coils on the upper side can be moved. The coils are formed by pinching from upper and lower side in a similar motion to folding a laptop computer.



### ● Diameter-Adjustable Method

The coil diameter changes automatically according to the dimensions of each workpiece, and this achieves optimum hardening. This has made it possible to reduce the number of coils used as well as the frequency of coil replacement.

## Crankshaft Induction Hardening & Tempering Equipment



The heating coil follows the workpiece to ensure stable hardening quality.

There are three target parts to be hardened on the crankshaft, which are the pin, journal, and flange parts. The pin part is located eccentrically with respect to the central axis and transfers reciprocating motion and rotational motion. DKK's hardening facility has a unique mechanism that allows the coil to follow the eccentric pin part, and it enables stable hardening of each machined part. Furthermore, we support both R-baking and flat-baking to suit your needs.

## Wide Range of Mechanical Methods

### ● Front-in Front-out Method

The workpieces are inserted from the front port and machined on the pin, journal, and flange parts before coming out from the same port. This is applicable for a wide range of workpiece sizes from small motorcycle parts to large parts for marine vessels.



### ● Turntable Method

This system carries workpieces on a rotating turntable. Every processing stage is located around the turntable, which saves approximately 40% of the required space needed, compared to conventional lifting or carrying style systems. It is suitable for relatively smaller sized workpieces for motorcycles and vehicles.



### ● Horizontal Transfer Method

The workpieces are inserted from one side and machined from pin part stage, journal part stage, and flange part stage, before coming out of the other side. The workpieces can be placed in any vertical or sideways position to pass through the facility. This is applicable for a wide range of workpiece sizes from small motorcycle parts to large parts for marine vessels.



## Motor Rotor Hardening & Tempering Equipment

### Induction Hardening of Motor Parts Indispensable for EV/HV

Hardening standards can be satisfied even in thin wall parts by performing low-distortion selective hardening on the outer diameter and inner diameter spline part, with a brief stationary one-shot induction hardening method.



## Supporting Various Workpieces

### ● Automobiles, Trucks, & Buses

We have a proven track-record of manufacturing various equipment according to the number of cylinders, from three to eight cylinders. Our team will suggest a variety of configurations to suit your needs including a hardening equipment supporting from three to eight cylinders in one unit.

### ● Other than automobiles

We also have a proven track-record of manufacturing crankshafts used in construction machinery, agricultural machinery, ships, generators, and motorcycles, etc.

# Automobile (Powertrain/Steering Components) & DKK

## Hub Unit Hardening/Tempering Equipment

Our equipment enables production of high-quality products with extremely low distortion rates even when the workpiece shape is complex.

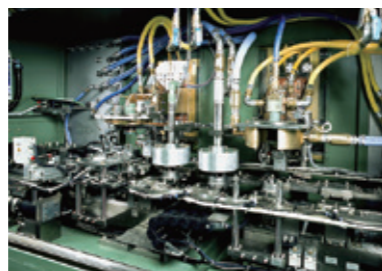


DKK's Hub Unit Hardening/Tempering Equipment provides satisfactory heat treatment quality on workpieces with a large diameter difference, grooves, or thin-walls. We will suggest the most appropriate facility system for your needs, from our standard technology to our unique high-frequency tempering technology (Denko-CARRIER HEATER, please refer to page #16).

## Wide Range of Mechanical Methods



Horizontal Transfer Method



Turntable Method

## CVJ Hardening/Tempering Equipment

Supports all types of workpieces, including pieces with short shafts to pieces with longer shafts.

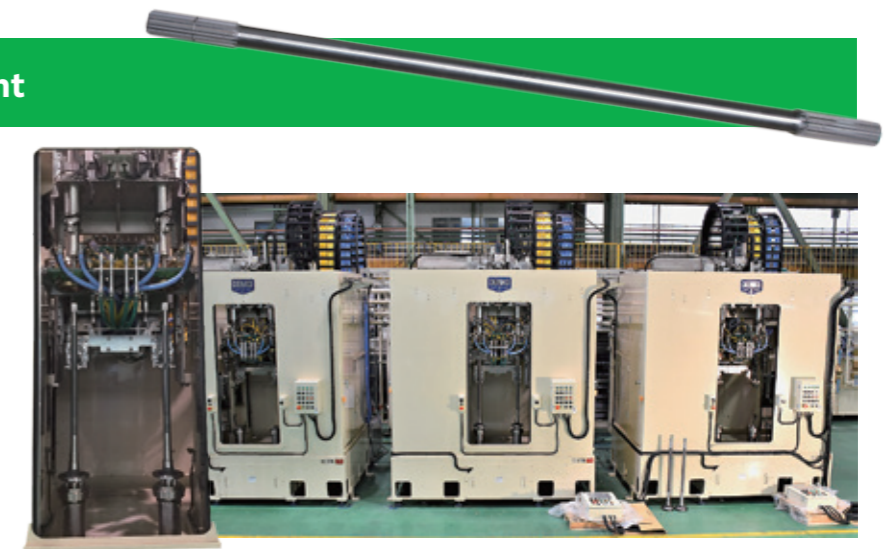
Supports all types of CVJ (Constant Velocity Joint) workpieces, including typical pieces with short shafts (tri-port joints and ball joints) to pieces with longer shafts, internal splines, and shaftless workpieces. Additionally, heating can be performed at the same position of the groove and shaft portions to shorten the processing tact time.



## Shaft Hardening Equipment

Supports a variety of long workpieces such as drive shafts and axle shafts.

In order to shorten cycle time, high-precision scanning hardening is made possible by processing two workpieces simultaneously. Additionally, the inductor scanning hardening system reduces height of the machine. A distortion suppression mechanism can be added as well.



## Rack Shaft Hardening/Tempering Equipment

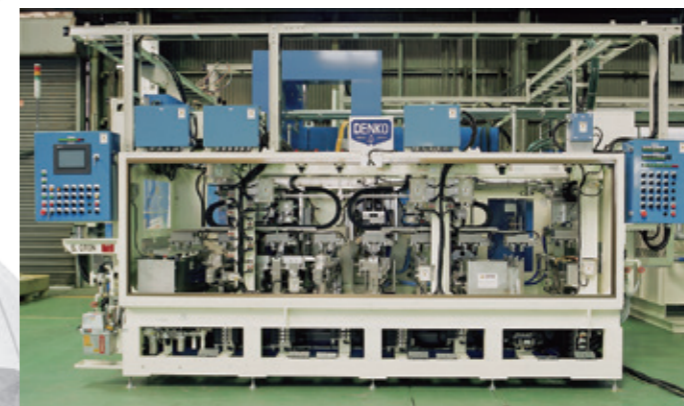
DKK proposes a wide range of solutions to meet your needs.

### ● Direct Energizing Heating Type Method

It hardens by applying high-frequency power current directly on the tooth surface and the back surface of the rack, with minimal distortion by aiming only at the necessary parts. We have many years of achievements with this method.

### ● Induction Heating Method

Arbitrary distortion adjustment is achieved with moving and hardening the entire circumference of the back face and tooth surface by providing a mechanism to straighten the workpiece back, forth, right and left during heating. On the ball screw type shafts, atmosphere hardening nitrogen gas is available to prevent oxidation during heating. We also support dual-frequency composite hardening in which the tooth flanks and the ball screws with different heat treatment specifications are transferred and hardened in a single process.



### ● Groove Portion Hardening

The high-precision phase determination function supports the hardening of tri-port joints. According to the hardening specifications, movable hardening or one-shot induction hardening is available.



### ● Shaft Portion Hardening

The hardening quality is ensured with sufficient hardening depth of the stepped portion of the shaft.



# Construction/Agricultural Machinery & DKK

DKK's hi-frequency induction heating equipment is also utilized to harden components for engines, powertrains, and crawlers of construction and agricultural machinery. Some of this equipment will be introduced below.

## Axle Tube Hardening & Tempering Equipment for Large Construction Vehicles

### Hardening & Tempering of Powertrain Components for Construction Machinery

It hardens/temper moving the heating coils while the power shaft part "axle tube" of larger construction vehicles rotates. The maximum possible heat treatment size is up to 400mm in external diameter, the hardening range is 1,200mm and the allowable upper limit weight of workpiece is 1,500kg.



## Crawler Hardening Equipment for Super-Large Construction Vehicle

### Process on Three Parts, the Tread, the Claw, and the Hole Continuously in One Equipment

It hardens the crawler track part for supersized excavators (width 800mm, depth 540mm, height 280mm, and weight 260kg). It enables hardening of the tread, stud claw (where the ground is gripped when running), and the hole (where the tracks are jointed through the pins), while feeding the workpiece sideways.



## Sprocket Hardening Equipment for Construction Vehicles

### Stationary Single-Shot Hardening on Large Sprocket for Crawler Tracks

It hardens the sprocket (gear part) of construction machinery, which transmits power to the crawler tracks. It enables stationary one-shot hardening of large components by using a high-output generator.

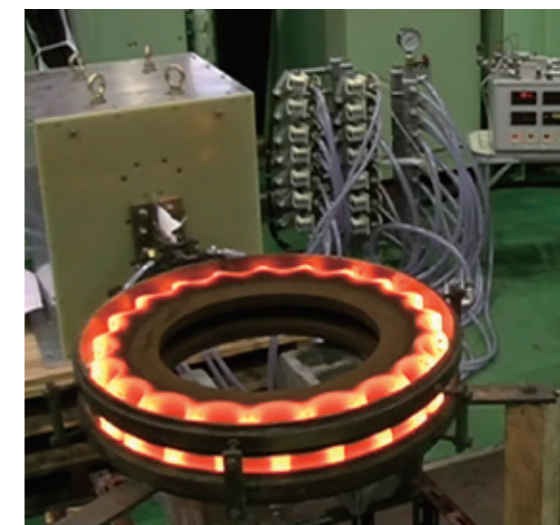


Photo shows the hardening of the sprocket with an outer diameter of 700mm, and the weight of 200kg.



## Hardening Equipment for Large Parts

### Hardening Large Workpieces Including 5m-long Shafts and Sprockets with an Outer Diameter of 800mm

Hardening of a wide variety of components is possible, including 5m-long shafts and sprockets with an outer diameter of 800mm.



The photo shows the hardening of the trolley for a gantry crane (outer diameter 500mm, height 100mm).



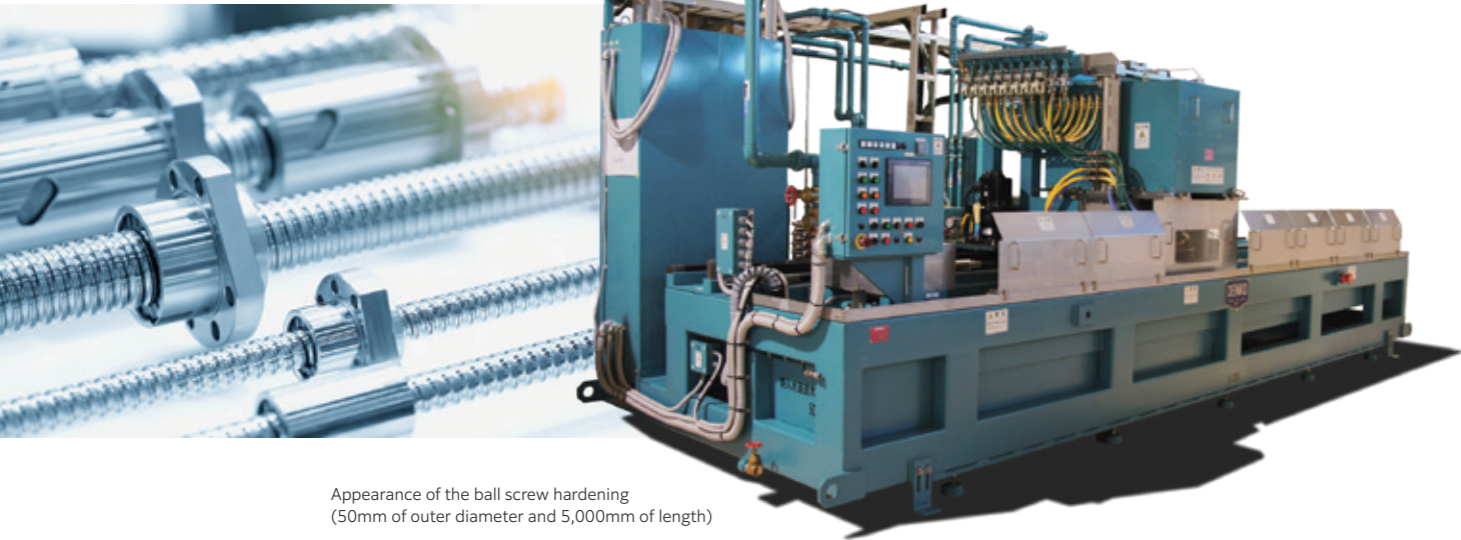
# Industrial Machinery & DKK

DKK's high-frequency induction heaters are widely used for hardening or annealing of ball screws, liner motion components or large-sized rings as well as paint drying, heating of wire rods and steel plates in the industrial machinery field. Some of the typical facilities are introduced below.

## Ball Screw Hardening Equipment

Enables to harden quite long ball screws up to 5,000mm.

Downsized the total length of the equipment by introducing horizontal coil-movable hardening method. We design and manufacture the equipment according to the required workpiece diameter and length.



Appearance of the ball screw hardening (50mm of outer diameter and 5,000mm of length)

## Seamless Hardening Equipment for Large-Sized Rings

Enables to harden large-sized rings for wind turbines seamlessly.

Whenever we carried out movable hardening large-sized rings, the conventional hardening method (one-way scanning) used to have a soft zone between the hardening start point and the end point. DKK achieves seamless hardening by using two coils at the same time and carrying out movable hardening in the opposite direction. With our unique hardening method bringing two coils close to each other at the start and end point, it enables to eliminate the soft zone in the hardening layer. (Patent No.: 5903455 Patent No.: 6146916 Patent No.: 6403960 Patent No.: 6671830)



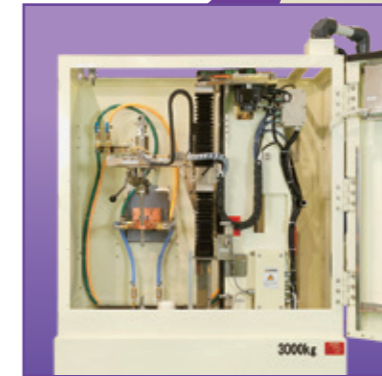
Enables to harden quite large rings up to 3,000mm of diameter.

# Innovations in Production Equipment

## DENKO-CUBO

Compact and General-Purpose Type High-Frequency Hardening Equipment

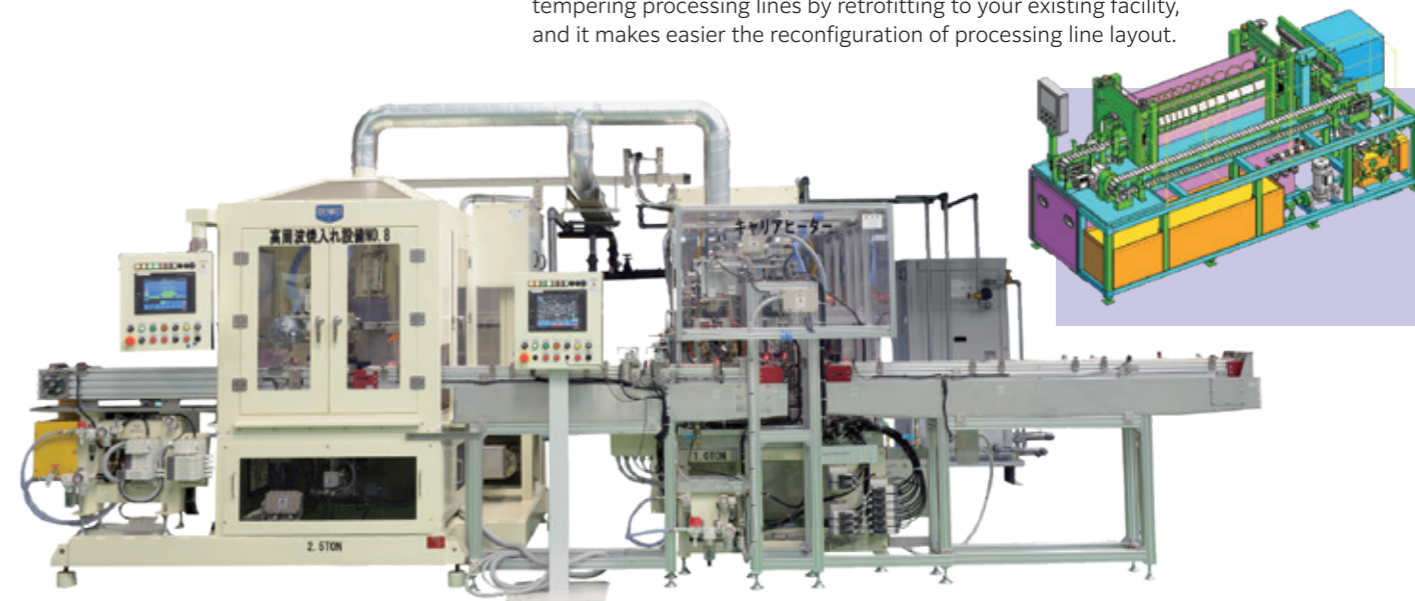
An innovative and neatly compact high-frequency hardening equipment integrating generator, control panel, machinery and water tank in one single cabinet. Transportable by one 4t truck and capable in a container, we have plenty of exporting experience as well as in Japan. In addition, it requires short period of time for start-up work.



## Denko-CARRIER HEATER

High-frequency induction heating achieves the same level of tempering quality as electric furnace.

Comparing to electric furnace, our high-frequency hardening equipment is energy-saving, space-saving, low-cost, shorter processing time and low emission of carbon dioxide. In addition, the same level of tempering effect as electric furnace can be obtained. Denko-CARRIER HEATER enables to automate all the hardening and tempering processing lines by retrofitting to your existing facility, and it makes easier the reconfiguration of processing line layout.



Introduction case example: High-Frequency Hardening Facility (left) and Denko-CARRIER HEATER (right)



# Global Environment & DKK

## Superheated Steam Generating Equipment

Superheated Steam Using High-Frequency Induction Heating to Reduce Food Waste (Extending the Shelf Life) and Drying Food Residue for Recycling (Reuse)

### What is superheated steam?

It is a clear and colorless water vapor generated from saturated steam evaporated at 100°C by heating at even higher temperatures. This technology is widely used in commercially available home electronics such as steam oven ranges etc.

### Mechanism of Superheated Steam Generation

It generates above 100°C water vapors by high-frequency induction heating, which is known to have zero direct emissions of CO<sub>2</sub>.

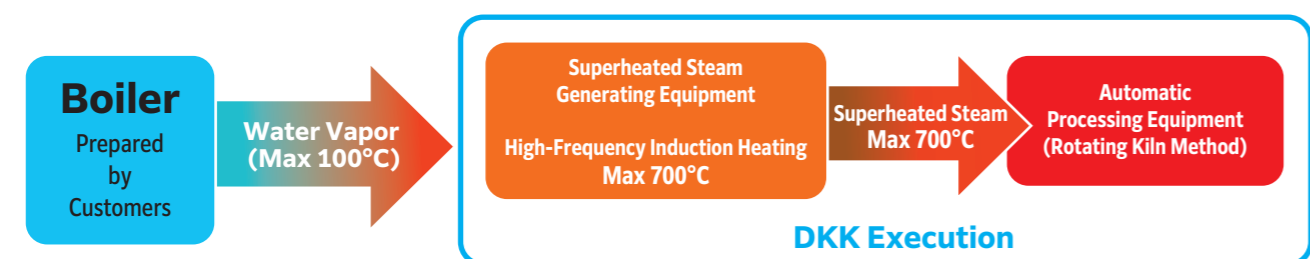


### Primary Uses

- Cooking
- Sterilization & Sanitization
- Antioxidation
- Drying

- (1) To effectively reduce the amount of food loss and waste by extending the expiration date of foods (Ex: Roasting coffee beans with Superheated Steam Generator)
- (2) To continually recycle food residue by drying garbage (Ex: Drying dripped coffee residue with Superheated Steam Generator)

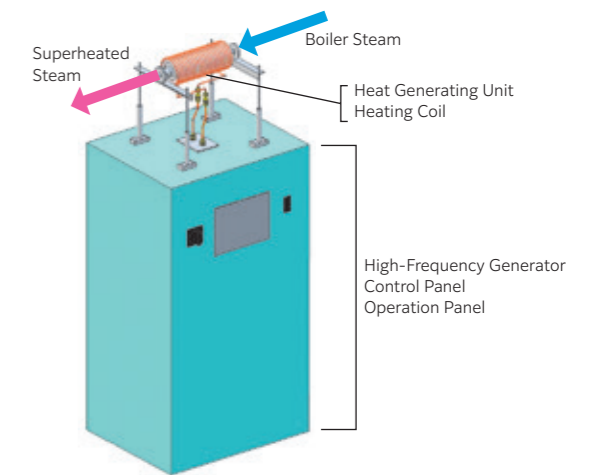
### Configurations



### Equipment Specification

Steam Supply Amount	Max 160kg/h	Max 450kg/h
Generator Type	PTG - 20 - 30	PTG - 20 - 100
Frequency	20kHz	
Generator Output	30kW	100kW
Power Supply Capacity	3Φ 200V/400V 50kVA	3Φ400V 150VA
Device Size (W × L × H)	1,000 × 800 × 1,820mm	

Steam Supply Amount: Require consultation if greater than 450kg/h



Superheated Steam Generating Equipment

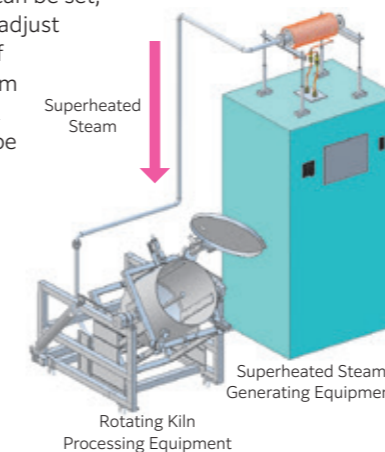
#### Usage Example 1

##### Rotating Kiln Method



Example: Roasting Coffee Beans

Superheated steam is fed into the inside of the kiln, heating the material while rotating it. The processing time can be set, making it possible to adjust the amount of time of the superheated steam irradiation (cooking & roasting). It can also be attached to a kiln you currently use.



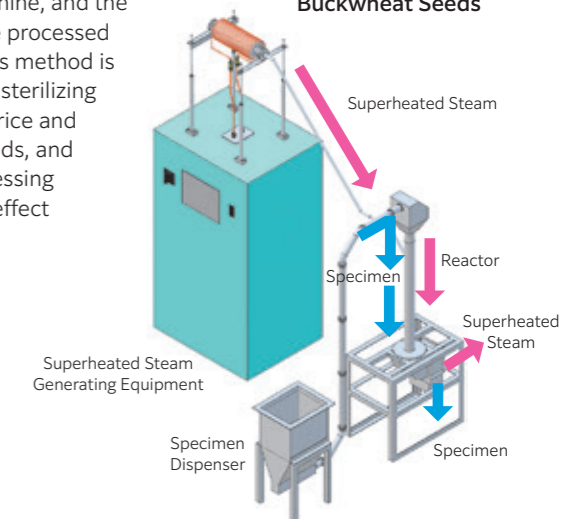
#### Usage Example 2

##### Drop Separation Method



Example: Buckwheat Seeds

Superheated steam and material (mainly grains) are fed in from the top of the machine, and the workpieces are processed as they fall. This method is well-suited for sterilizing grains such as rice and buckwheat seeds, and the short processing time has little effect on their taste.



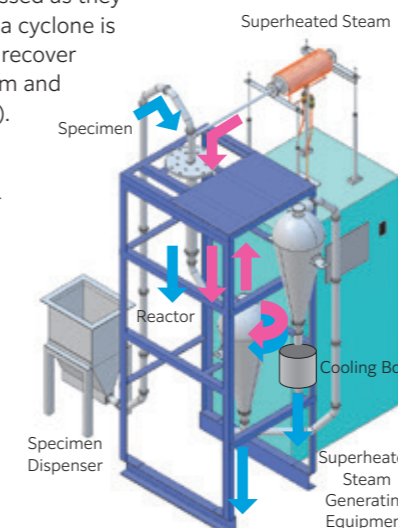
#### Usage Example 3

##### Cyclone Method



Example: Rice Bran

Superheated steam and material (mainly powder) are fed in from the top of the machine, and the workpieces are processed as they fall. After processing, a cyclone is used to separate and recover the superheated steam and the material (powder). This method can be used for sterilization of rice bran and other such materials, and has a proven track record of use for commercialization.



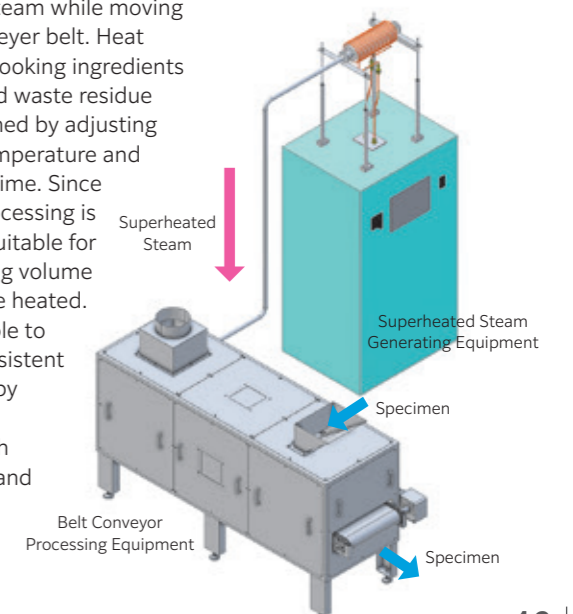
#### Usage Example 4

##### Belt Conveyor Method



Example: Vegetables

Feed processing materials into the equipment and irradiate with superheated steam while moving along the conveyor belt. Heat treatment on cooking ingredients and drying food waste residue can be performed by adjusting the internal temperature and the operation time. Since continuous processing is possible, it is suitable for large processing volume of objects to be heated. It is also possible to perform in consistent line operation by connecting the equipment with the preceding and the following processes.



# DKK's Global Network

We have 5 production/maintenance companies as well as heat treatment processing/partner companies in 4 countries overseas in order to keep our equipment in perfect condition through regular maintenance, and to be able to respond quickly in case of emergency.



## DACPOL Co., Ltd. (Business Affiliate Partner)

Facility Maintenance Service, Heating Coil Business

Pulawska34  
05-500 Piaseczno/WARSAW  
Poland  
TEL : +48-22-703-51-00  
FAX : +48-22-703-51-01

## KOREA DENKI KOGYO Co., Ltd. (Production Base)

Facility Manufacturing, Facility Maintenance

18, Namdongdong-ro 33beon-gil, Namdong-gu Incheon, Korea  
TEL : +82-32-713-8850  
FAX : +82-505-070-8850

## DKK (SUZHOU) HEAT TREATMENT Co., Ltd. (Production Base)

Facility Manufacturing, Facility Maintenance, Heating Coil Business

2, NO3888, LINHU AVENUE, WUJIANG DISTRICT, SUZHOU CITY, CHINA  
TEL : +86-0512-63263655

## DKK (THAILAND) Co., Ltd. (Production Base)

Facility Manufacturing, Facility Maintenance, Heating Coil Business

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TEL : +66-23-319-860

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Okazaki Business Office

4-1 Kiyokuchi, Kamimitsugi-cho, Okazaki-shi,  
Aichi 444-0246  
TEL : +81-564-57-6560  
FAX : +81-564-57-6789

Osaka Branch

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Osaka 564-0051  
TEL : +81-6-6378-0162  
FAX : +81-6-6378-0163

## Production Bases

Atsugi Plant, Radio Frequency Division

4052-1 Nakatsu, Aikawa-machi, Aiko-gun,  
Kanagawa 243-0303  
TEL : +81-46-285-1411 (main)  
FAX : +81-46-285-2298

## Entrusted Heat Treatment Base

Denko Techno Heat Co., Ltd.

Kariya Plant (Headquarters)

15 Ogumi, Hajodo-cho, Kariya-shi,  
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TEL : +81-566-21-0681 (main)

Atsugi Plant

4052-1 Nakatsu, Aikawa-machi, Aiko-gun,  
Kanagawa 243-0303  
TEL : +81-46-286-8175 (main)  
FAX : +81-46-286-1065

Hamamatsu Plant

170 Tsumori-cho, Minami-ku, Hamamatsu-shi,  
Shizuoka 430-0815  
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Suzuka Plant

1820-39 Mikkaichi-cho, Suzuka-shi,  
Mie 513-0803  
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Shiga Plant

10 Satsukigaoka, Minakuchi-cho, Kouka-shi,  
Shiga 528-0062  
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## DKK of America, Inc. (Maintenance Base)

Facility Maintenance Service, Heating Coil Business

6345 South Inwood Drive Columbus IN 47201, U.S.A.  
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## DTHM, S.A. DE C.V. (Maintenance, Entrusted Heat Treatment Base)

Leon Plant: Entrusted Heat Treatment

William Thomson 103 int.A Col.Parque Industria Leon-Bajio, C.P.37680 Leon,  
Guanajuato, Mexico  
TEL : +52-477-689-1279

Abasolo Plant: Entrusted Heat Treatment, Heating Coil Business

Calle Jose Maria Pascual No.202, Parque Industrial Marabis, Abasolo,  
Guanajuato Cp. 36970 Mexico

## We also have facilities who undertake entrusted heat treatments.

Denko Techno Heat and DTHM provide consigned processing services for heat treatment using our induction heating equipment.

